Remote Sensing of Surface Currents Associated with the Chesapeake Bay Outfall Plume Using a Shore-Based HF Radar

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LONG-TERM GOAL

To understand the dynamics and temporal and spatial variability of the dynamics of the outflow plume and its subsequent transition to a coastal jet using the combination of VHF/HF radar observations as well as additional moored, shipborne and remotely sensed data.

SCIENTIFIC OBJECTIVES

1. To characterize the space/time scales of the outflow plume variability embedded within a mesoscale flow regime.

2. To interrelate remotely-sensed signatures from OSCR/INSAR/Ship radar measurements by examining the salinity front and buoyant jet trapped against the coast.

3. To estimate horizontal advection, shear and vorticity associated with the mean and tidal flows.

4. To assess horizontal mixing effects between the fresh water from the outflow plume and the coastal ocean through the interaction of various current components.

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5. To examine the residual patterns of the surface layer outflow and how they are influenced by varying wind regimes;

APPROACH

HF radars provide a unique opportunity to measure surface currents, surface gravity waves and wind speed and direction at high spatial and temporal resolution and over a large domain. The HF mode of the OSCR system was deployed for two months (October and November 1997) at Fort Story (Cape Henry) and the US Navy Fleet Combat Training Center Atlantic. These locations were chosen to catch the plume as it emerges from the bay and turns southward due to ambient flow and Coriolis forcing. Two additional HF radars, the SeaSonde system (Naval Postgraduate School) and the multi-frequency system (University of Michigan) were colocated with the OSCR. This study will permit intercomparison of three HF radar systems with different technical implementations, namely, single frequency, linear phased-array, single frequency, direction finding technique and the multi-frequency, linear phased-array.

WORK COMPLETED

1. A data report describing the OSCR measurements for the first Intensive Observation Period of COPE-I (September 1996) is completed.

2. A summer student study on the analysis of a SAR image of the Chesapeake Bay estuary plume was completed.

3. A manuscript on the strength of the M_2 tidal currents was submitted.

4. All surface vector currents from COPE-III have been processed and quality controlled and tidal currents, mean (low-pass), band-pass and high-pass current fields were computed.

5. All Doppler spectra for the two-month long measurement period (COPE-III) have been processed and the total energy under the first and second-order peaks are computed.

6. Intercomparison of three radar system is in progress.

RESULTS

Our results from the first measurement period (COPE-I) show that the surface currents in the Chesapeake mouth region are forced by a combination of tides, river discharge, buoyancy and wind. The primary tidal constituent is the M_2 tide which has an amplitude of ~21 cm/s in the east-west direction. Figure 1 shows the measured tidal ellipses for the M_2 and K_1 constituent during COPE-I. The rotary nature of the K_1 tide is much stronger than for the M_2 tide over much of the domain.

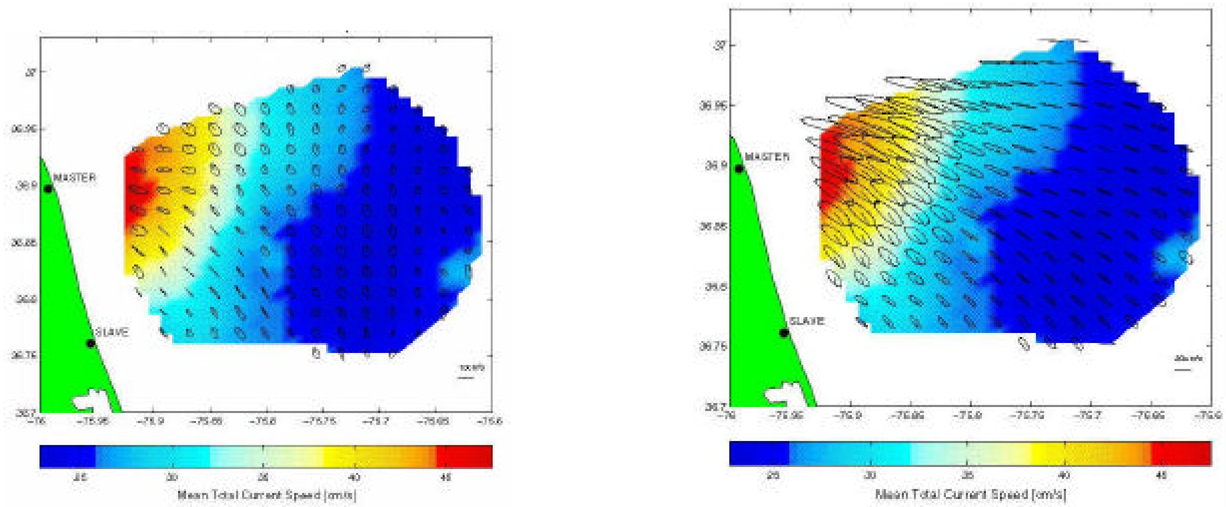

Figure 1: The K_1 (left panel) and M_2 (right panel) tidal ellipses measured during the COPE-I experiment (Haus et al. 1998).

The semi-diurnal tidal currents are highly correlated over much of the HF-radar domain. Complex correlation analysis indicate a consistent anticyclonic veering of the M_2 component. Tidal vorticities associated with the M_2 constituent were ±0.25 f where f is the local Coriolis parameter. From ADCP analyses in the HF-radar domain we find that the semi-diurnal tidal currents are pre-dominantly barotropic in this region. Figure 2 shows the complex correlation coefficients and phases from the COPE-I measurements relative to cell 125 in the strong tidal regime.

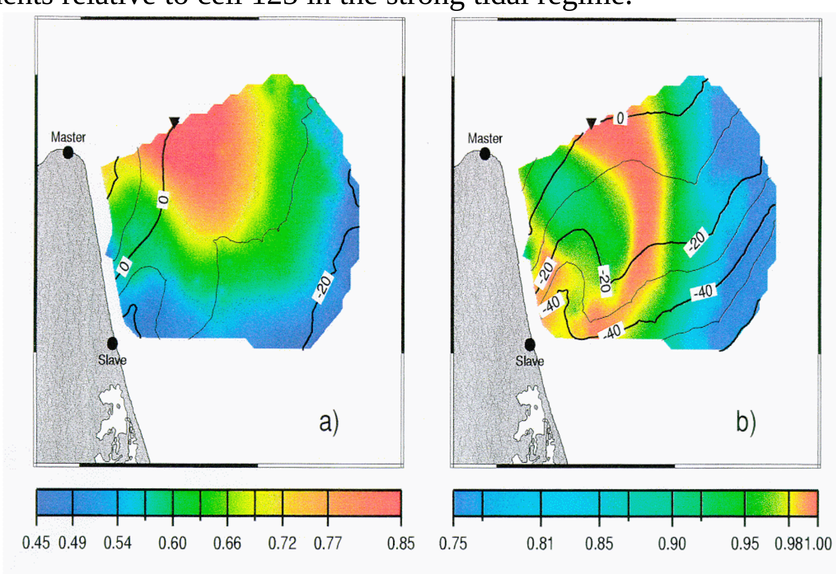

Figure 2: Complex correlation coefficients (color) and phases (contours) from COPE-I relative to cell 125 (triangle) in the strong tidal regime for (a) observed surface currents and (b) M_2 tidal currents (Shay et al. 1998).

IMPACT/APPLICATION

The studies of high-resolution surface current and wave height estimates with HF radar systems provide a continuous new look at small-scale dynamics affecting coastal and nearshore processes. From the tidal analysis we can describe the spatial variability of the dominant tidal components in this region. In

particular our measurements show the directivity of the tidal flow as a function of offshore distance as well as the domination of a single tidal component (M_2) versus mixed tidal conditions.

TRANSITIONS

We continue to collaborate with both NRL-Washington and NRL-Stennis in providing surface current measurements for the analysis of other remote sensing, shipboard and in-situ measurements.

RELATED PROJECTS

The successful applications of the HF-radar system to coastal oceanography let to the development of a new multi-frequency HF radar system under the STTR program.

REFERENCES

Haus, B.K., H.C. Graber, L.K. Shay, S. Nikolic and j. Martinez, 1998: Ocean surface current observations with HF Doppler radar during the Chesapeake Outflow Plume Experiment (COPE-I). **RSMAS Tech. Rep. 98-003**, University of Miami, 71pp.

Shay, L.K., T.M. Cook, B.K. Haus, H.C. Graber, J. Martinez, and Z.R. Hallock, 1998: The strength of the M2 tide at the Chesapeake Bay. In preparation.

PUBLICATIONS

Harvey, R.S., 1998: Analysis of a SAR image of the Chesapeake Bay estuary discharge plume. Summer Undergraduate Fellowship Program Report, University of Miami, 18pp.

Haus, B.K., H.C. Graber, L.K. Shay, S. Nikolic and j. Martinez, 1998: Ocean surface current observations with HF Doppler radar during the Chesapeake Outflow Plume Experiment (COPE-I). **RSMAS Tech. Rep. 98-003**, University of Miami, 71pp.

Marmorino, G.O., L.K. Shay, B.K. Haus, R.A. Handler, H.C. Graber, and M.P. Horne, 1998: An EOF analysis of HF Doppler radar current measurements of the Chesapeake Bay outflow. *Cont. Shelf Res.*, in press.

Shay, L.K., T.M. Cook, B.K. Haus, H.C. Graber, J. Martinez, and Z.R. Hallock, 1998: The strength of the M2 tide at the Chesapeake Bay. In preparation.